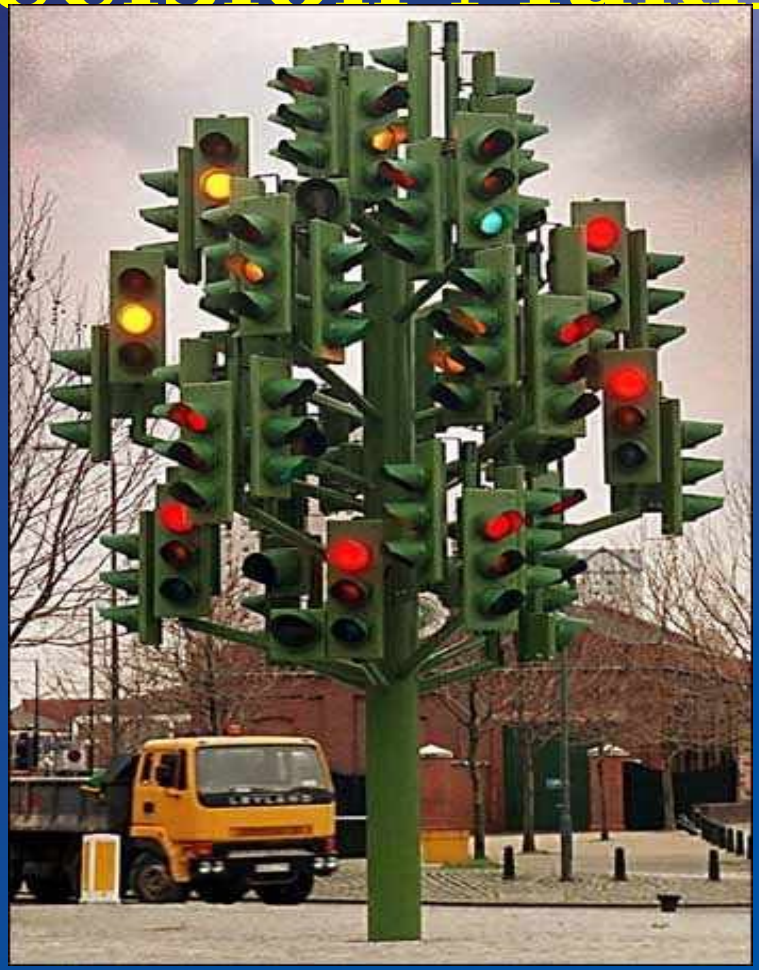
How Effective Post-Mortems can Improve Decision Making



Overview

I. Value of post-mortems
- Increased understanding
- Lead to better research/training
- Create database of contributing factors

II. Protocol for performing
- What some offices are doing
- HQ examples
- Root cause analysis

I. Value of a Post- Mortem

- *n*. 2 short for POST MORTEM EXAMINATION (*AUTOPSY*); a detailed examination or evaluation of some event just ended

"Post-mortem examinations provide valuable information … and can provide vital information for future treatment and research." *(Royal College of Pathologists)*

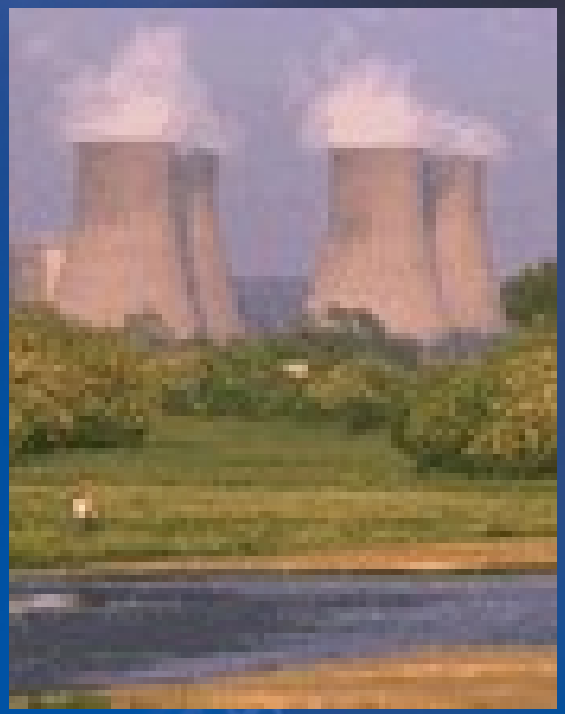
Finding out what happened

What do other disciplines do?

Post-Mortems

Root Cause Analysis

Proximal Cause



Accident Investigations

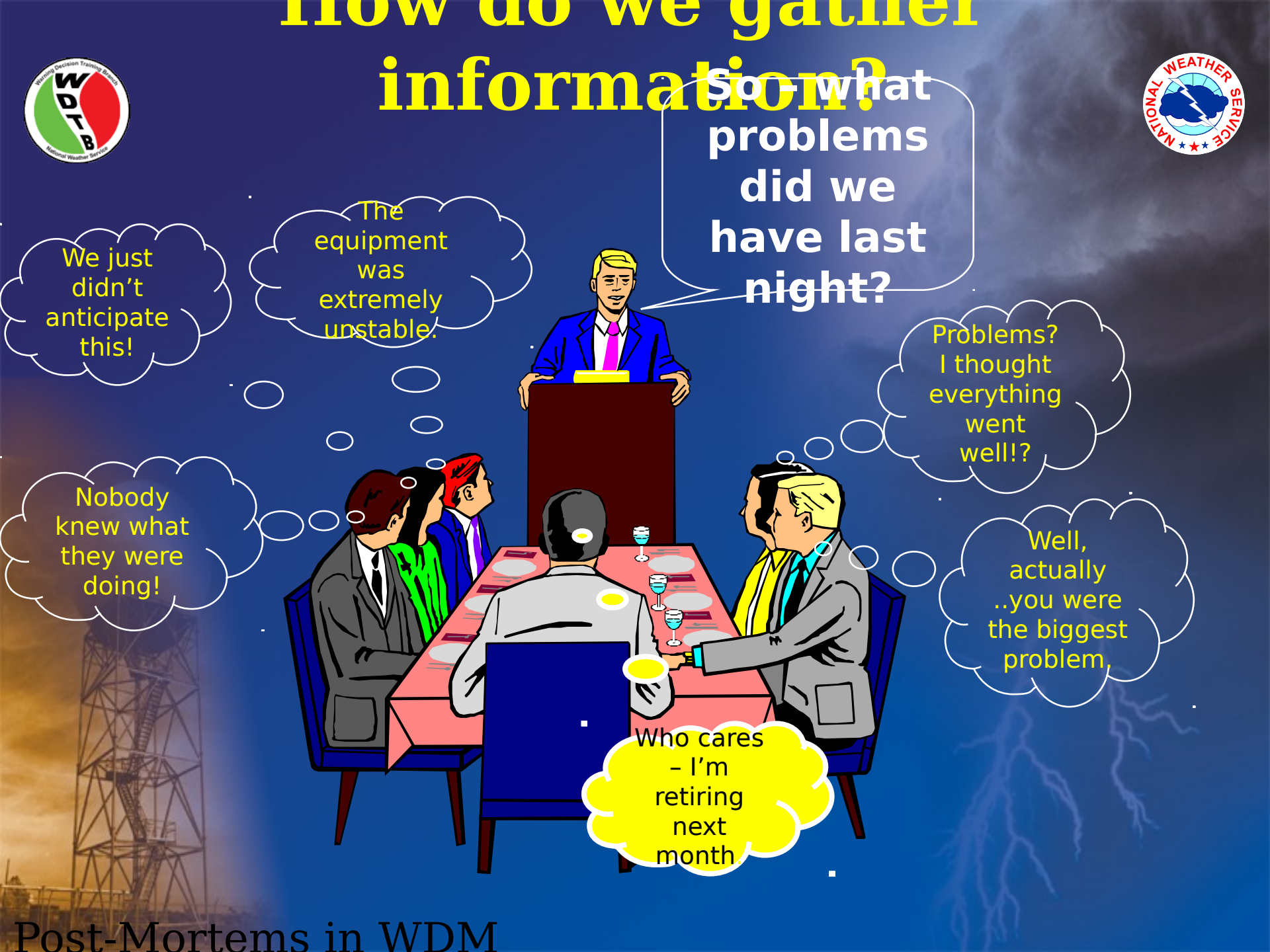
The National Transportation Safety Board

- Aviation
- Highway
- Marine
- Pipeline & Hazardous material
- Railroad

WB-Graph
(Why-Because)

Post-Mortems in WDM

How do we gather information?



Post-Mortems in WDM

Not all Post-Mortems are created equal

"It does not appear to get at the underlying issues of why these things occur."

Bernard Loeb,

NTSB aviation accident investigation branch chief (ret)
(regarding repeat issues raised in NTSB reports)

USA Today 3/22/2002

Post-mortems can help us learn from our successes…

Success

…is what happens when preparation meets with opportunity.

….and learn from our mistakes

MISTeAKES

It Could Be That the Purpose of Your Life is Only to Serve as a Warning to Others.

Post-mortems can help us fix what's wrong…and leave alone what's right

"A prescription without a diagnosis is malpractice."

- Socrates

Why are some Post-Mortems ineffective?

- **Incomplete problem definition**
  - ***A common misperception is that we all see the same thing***
- **Categorical thinking**
  - **Deciding on the cause before investigating**

> "The history of the field is littered with brilliant scholars who completely missed the boat because of the power of their preconceptions."

Mark Davis, *Into the Fray* (PBS)

Why are some Post-Mortems ineffective… cont

- **Causal relationships are unknown**
  - ***Storytelling can omit conditional causes***
    - ***Includes who,what, and when but not <u>why</u>***
- **Solution oriented**
  - ***"Favorite solution" mindset***
    - ***More important to work in "preferred" solution than to understand the cause***

Apollo Root Cause Analysis,

What can happen when the fix is implemented without understanding the problem

Problem: FAA records showed runway incursions on the increase.

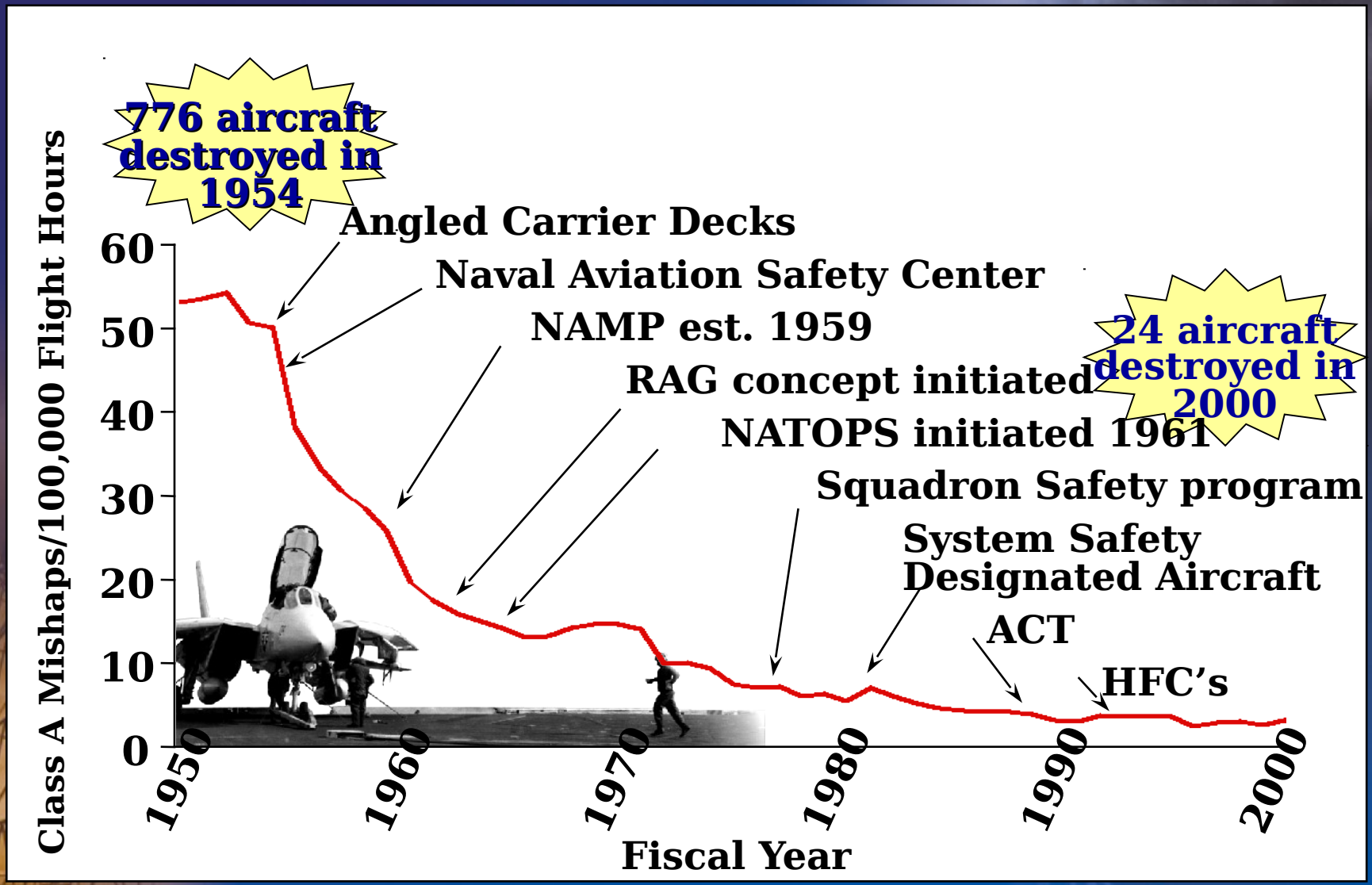
Solution: Paint wider stripes at intersections so pilots can see them.

Results: Runway incursions continued to increase.

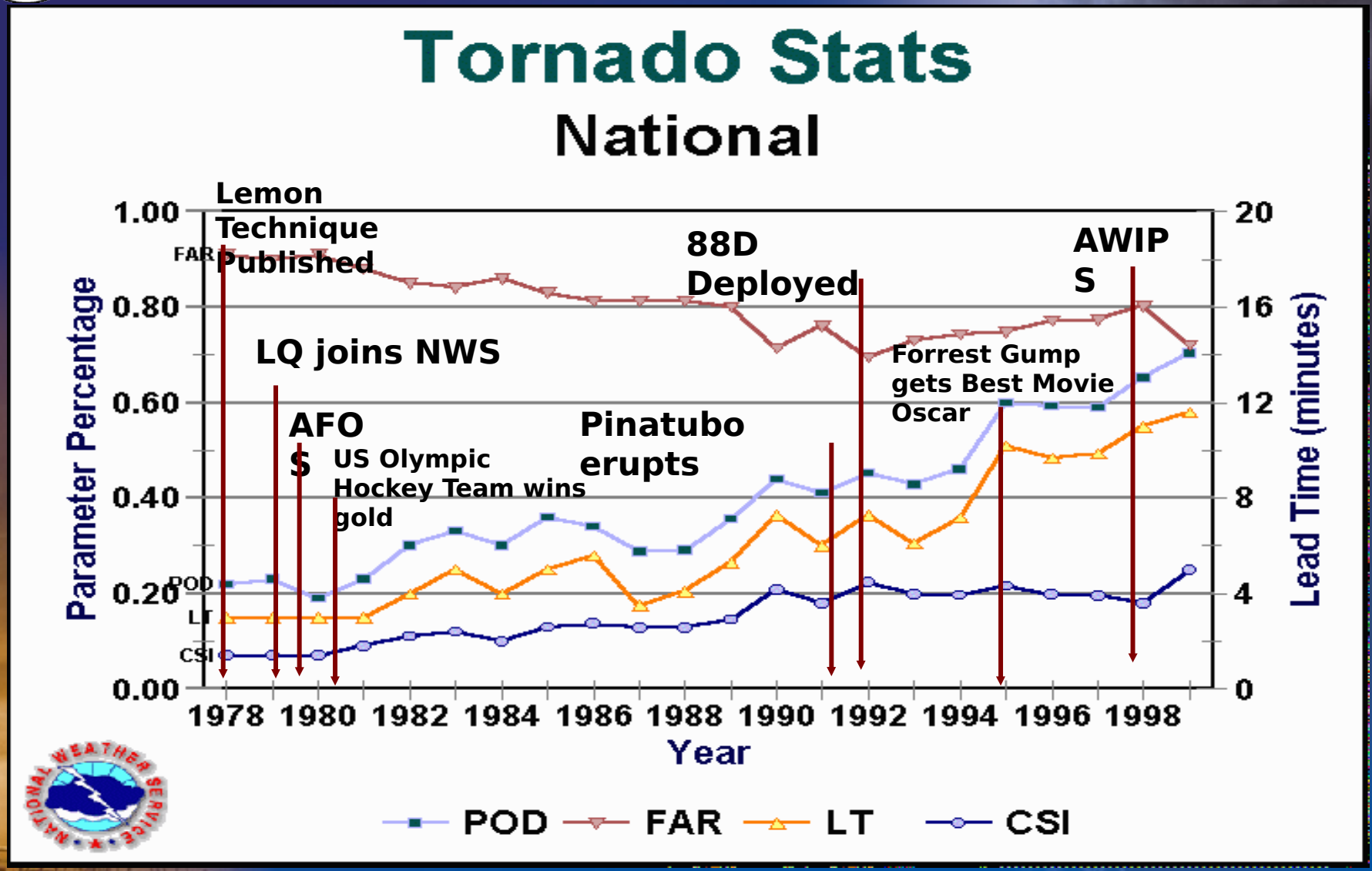
Upon further review: Turns out most incursions were ***not*** caused by pilots failing to see intersection lines.

NAVAL AVIATION MISHAP RATE

Compared with various events

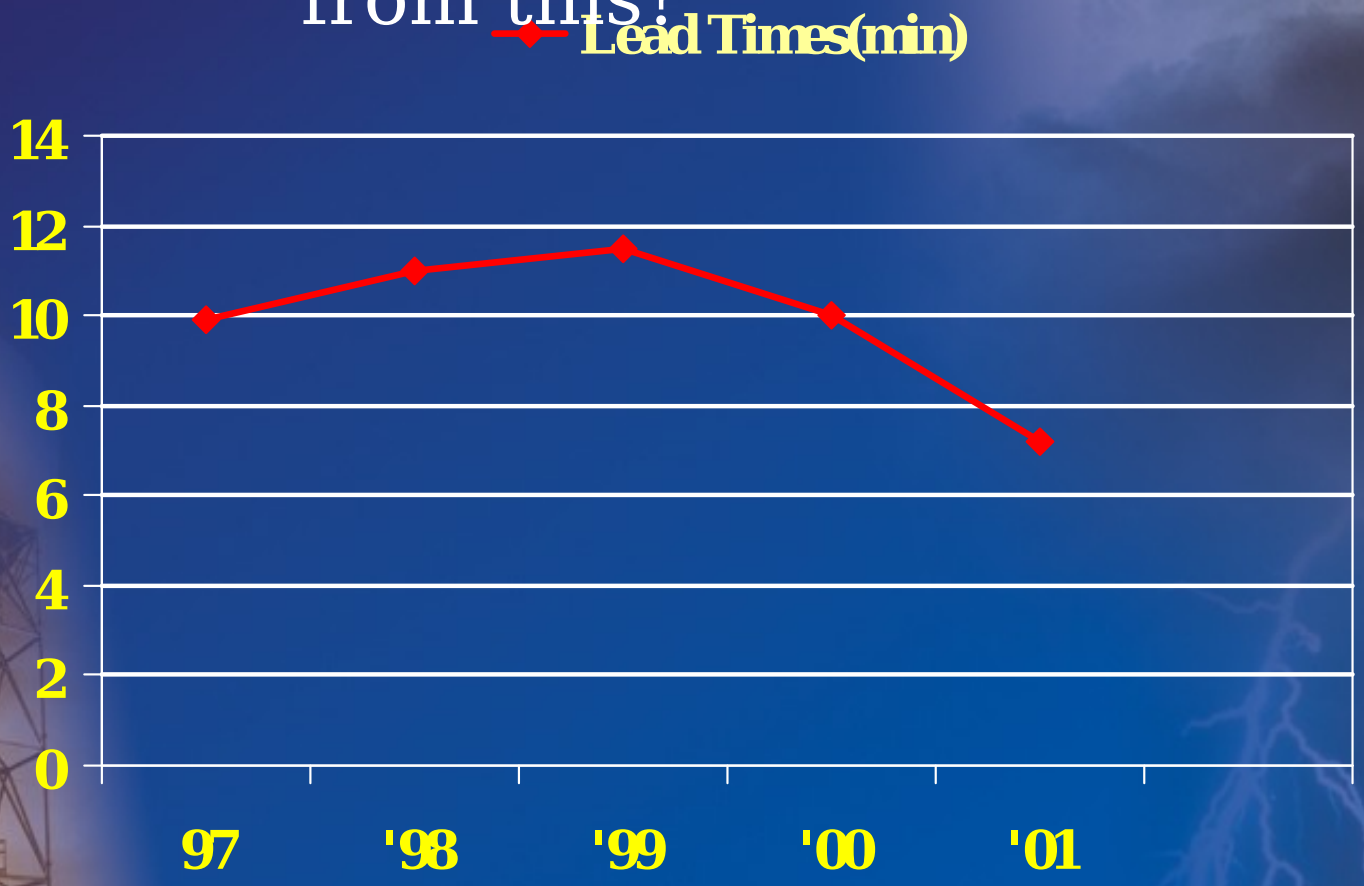


NWS Tornado Stats
Compared with various events



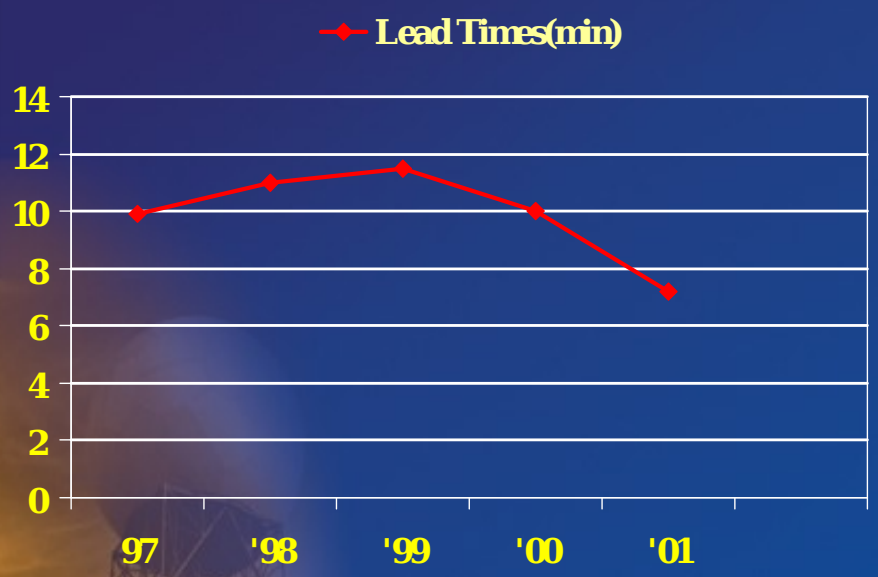
Tornado Lead Times
(National)

What do we infer from this?



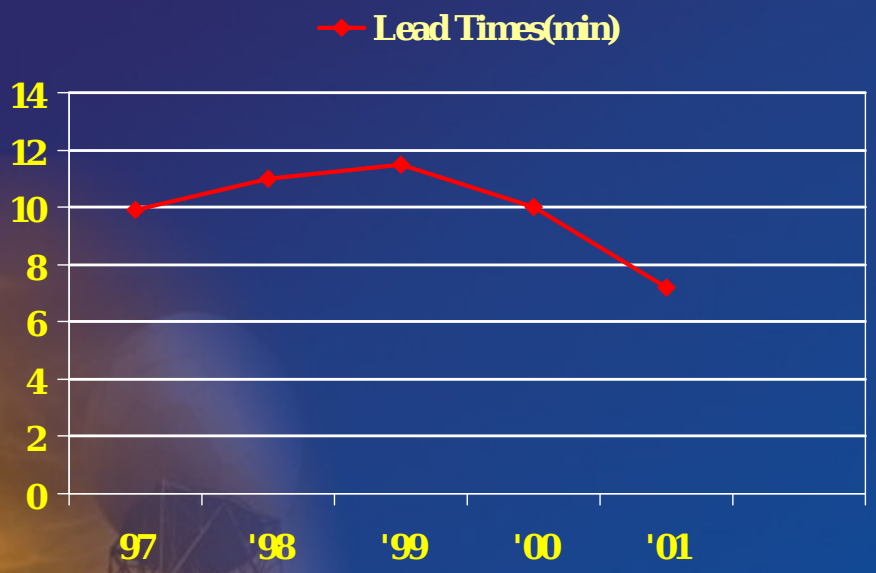
From NWS OS Briefing July 2001

What this chart doesn't tell us about individual events



- What was F-scale of each?
- What was time of day?
- What was range of each?
  - How did radar(s) sample?
  - How well did other sensors sample?
- How well was event anticipated?
  - Were there environmental clues?
- How well did staff work together?
- What was experience level of staff?
- What was maximum expected lead time in "best case scenario"?
- Was the "best decision" made given the inputs and limits of

What this chart doesn't tell us about individual events



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- How well was event anticipated?
  - Were there environmental clues?
- How well did staff work together?
- What was experience level of

If we can't answer these questions, how do we know what to leave alone and what to fix?

”?

given the inputs and limits of

Traditional Post-Mortems have not been Multi-disciplinary

"Given an identical problem, an engineer will find an engineering solution, a programmer will find a programming solution, and a sociologist will find a societal solution. A best solution will often involve all three."

Dr. Dennis Mileti
Director , Natural Hazards Center

When you have a Post-Mortem with entries like this…

Compensation For Wind Conditions Inadequate
Distance Misjudged
Flare Delayed
Ground Loop/Swerve Intentional
Remedial Action Delayed
VFR Flight Into IMP Initiated
Visual Lookout Not Maintained
Compensation for Wind Conditions Imp
Directional Control Not Maintained
Diverted Attention
Ice/Frost Removal From Aircraft Inade
IFR Procedure Improper
Aircraft Control Not Possible
Stall Inadvertent
Inadequate Visual Lookout
Lack of Familiarity With Aircraft
Lack of Total Experience in Type of Aircraft

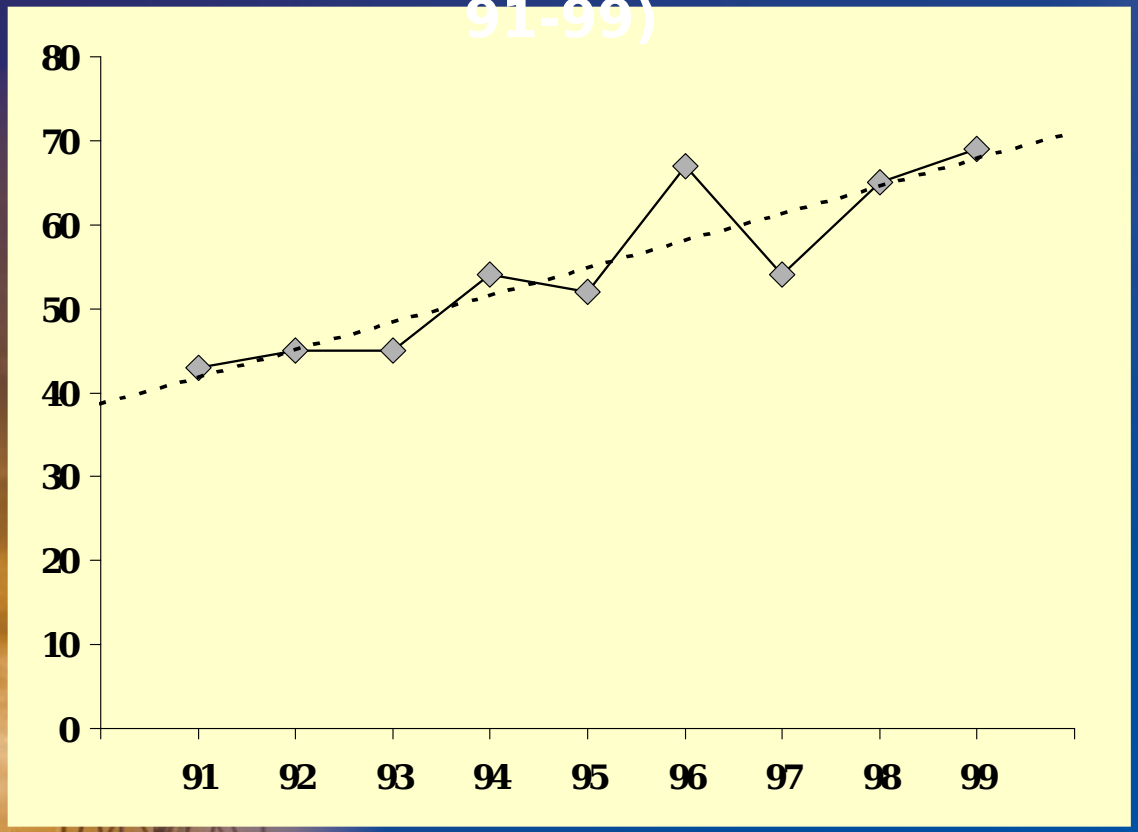
Sample entries in Naval Safety Center accident database

Lowering of Flaps Performed
VFR Flight Into IMC Inadvertent
Aborted Takeoff Performed
Communications Not Understood

Emergency Procedure Not Followed
Inadequate Weather Evaluation
Procedure Inadequate
VFR Flight into IMC Continued
Emergency Procedure Not Performed
Lack of Familiarity with Geographic Area
Maintenance, Adjustment Improper
Monitoring Inadequate
Remedial Action Not Possible
Visual/Aural Perception
Preflight Planning/Preparation Inadequate

You can then get answers with statistics like this

Percentage of Human Error Mishaps Associated with skill-based Errors (FY 91-99)

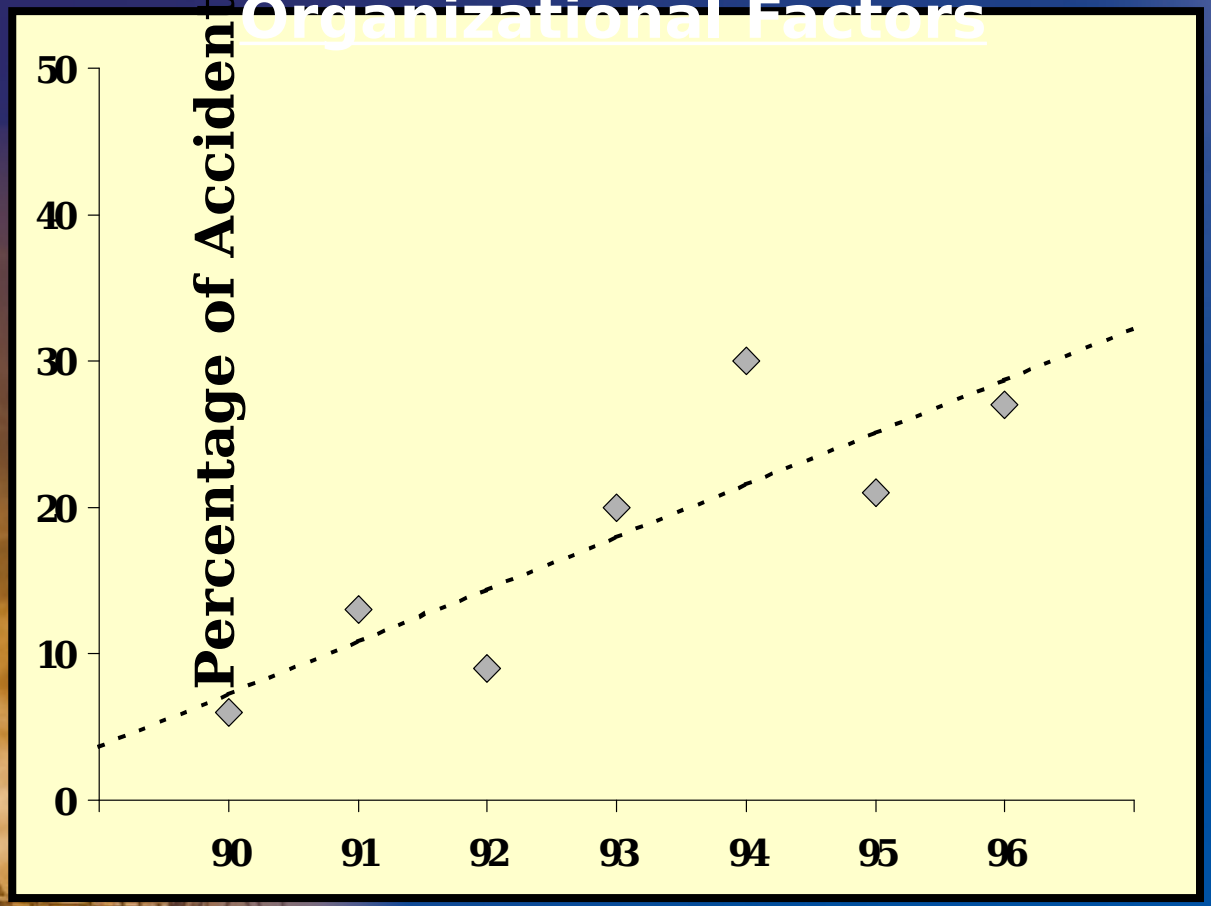


Skilled – based Errors are:

- Poor technique
- Improper use of equipment
- Omitting required procedures
- Failure to observe critical data

…and this

Aircrew-related accidents involving Supervisory or Organizational Factors



Supervisory/ organizational factors:

- Inadequate training
- Poor crew pairing
- Improper delegation of authority
- Organizational climate (unofficial rules, attitudes)

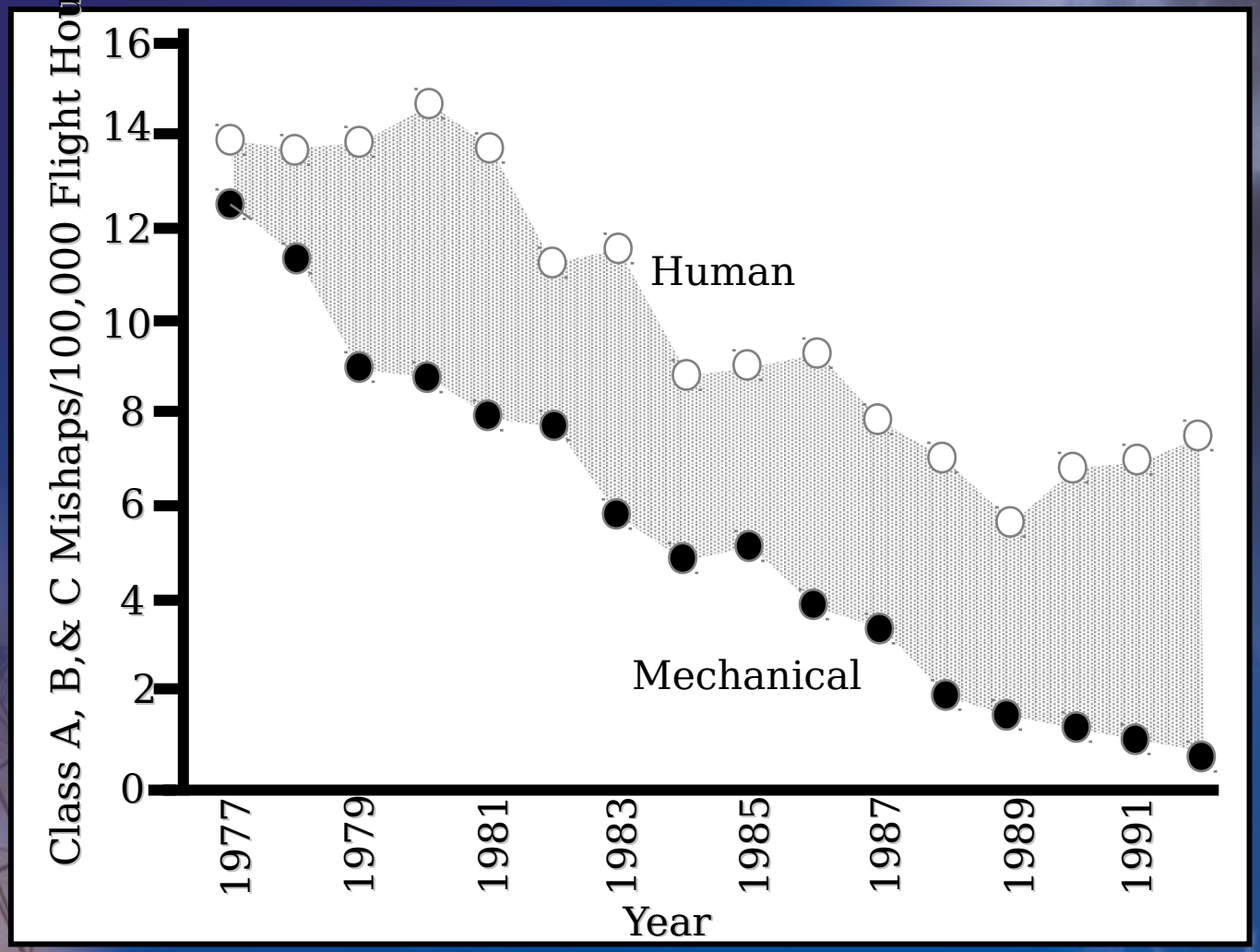
A fundamental issue

"Human beings by their very nature make mistakes; therefore, it is unreasonable to expect error-free human performance."
Shappell & Wiegmann, 1997

- **It is not surprising then, that human error has been implicated in 60-80% of accidents in aviation and other complex systems.**
- **In fact, while accidents attributable to mechanical factors have been greatly reduced over the last several years, those attributable to human error continue to plague organizations.**

Aviation industry findings

Mechanical errors decreased, human error



Shappell, S. and Wiegmann, D. (1996). U.S. Naval aviation mishaps 1977-1992 All NAVY/MARINE Class A, B, & C Mishaps

Some possible explanations

- **Systems induce human error**
  - ***Often don't account for human need to understand the state***
- **Implementing "fail safe" measures can lead to higher risk behavior**
  - ***Anti-lock brakes***
  - ***Ground proximity warnings systems***
  - ***Stop lights***
  - ***The "unsinkable" Titanic***
  - ***Algorithms/ decision aid tools***
    - ***Easy to forget that the safety net has holes!***
- **Not getting good feedback on human contribution to accidents**

Accident Investigation for mechanical failures

Research Sponsors

- FAA, DoD, NASA, & Airlines…
- Programs are needs based and data driven. Interventions then are very effective.

***Data-Driven* Research**

***Effective* Intervention and Prevention Programs**

Prevention

Mitigation

Mechanical Failure

- Catastrophic failures are infrequent.
- When they occur, they are often less severe or hazardous due to effective intervention programs.

ACCIDENT

Accident Investigation

- Highly sophisticated techniques and procedures
- Info is objective and quantifiable.
- Effective at determining why failure occurred

Accident Database

- Designed around traditional categories
- Variables are well-defined and causally related.
- Organization and structure facilitate access and use.

Database Analysis

- Clearly outlined and readily performed.
- Frequent analysis helps identify common safety issues.

Feedback

Post-Mortems in WDM

Accident Investigation for Human Error

Research Sponsors

- FAA, DoD, NASA, & Airlines…
- Lack of good data - research based on interests and intuitions. Interventions then less effective.

Fad-Driven Research

Ineffective Intervention and Prevention Programs

Prevention

Mitigation

Human Error

- Errors cause most major accidents
- Ineffective at preventing the occurrence or consequences of errors.

ACCIDENT

ACCIDENT

ACCIDENT

Accident Investigation

- Unsophisticated procedures
- Information is qualitative and illusive
- Focus on "what" happened but not "why" it happened

Accident Database

- Not designed around any particular human error framework
- Variables ill-defined
- Organization and structure difficult to understand

Database Analysis

- Traditional HF analyses hard due to ill-defined variables and database structures.
- Underlying HF safety issues rarely uncovered.

Feedback

Post-Mortems in WDM

Addressing the Problem

- Make perfect systems and take the human out of the process?

But until then…

- Create an error framework including the human aspects around which incident investigation and prevention programs can be developed.

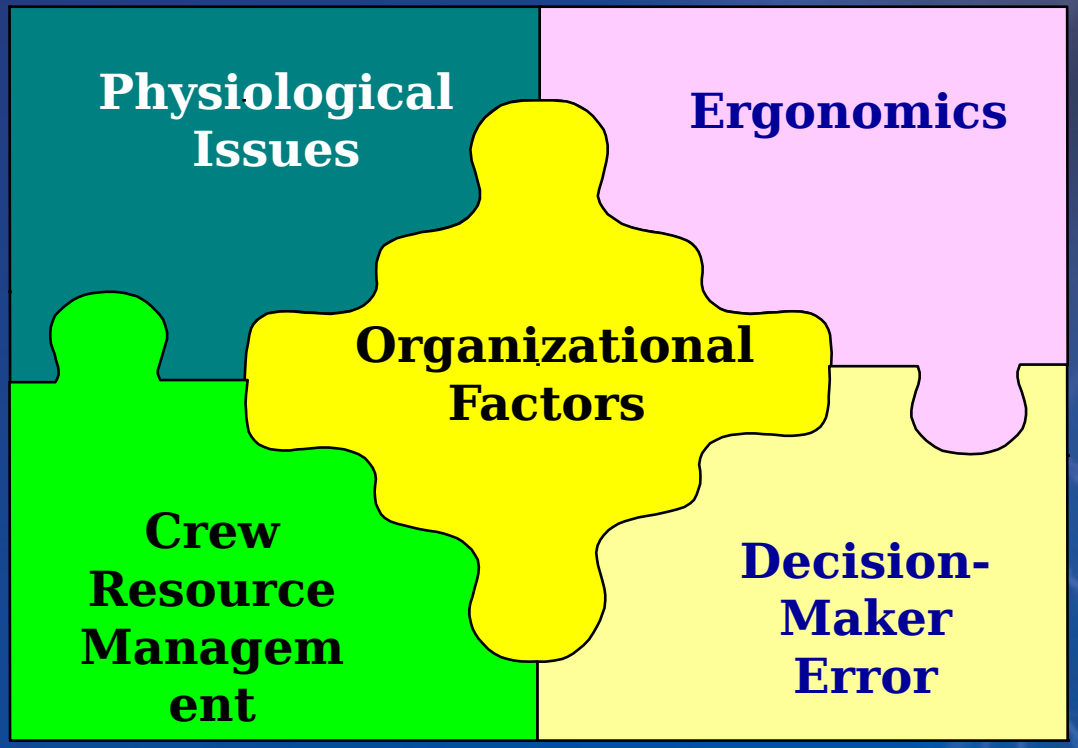
Effective Post-Mortems must address all aspects of the task

- **Science***
  - ***Application, limitations***
- **Technology***
  - ***Application, limitations***
- **Human Factors**
  - ***Personal, organizational, customer****
- **And the interactions amongst all three**

*What is traditionally covered (to varying degrees) in NWS post-mortems

Human Factors Analysis and Classification System (HFACS)*

A method of capturing the Human side of the post-mortem



*Wiegmann and Shappell,

HFACS: Guiding Principles

Principle 1: Aviation is similar in nature to other complex productive systems.

Principle 2: Human errors are inevitable within such a system.

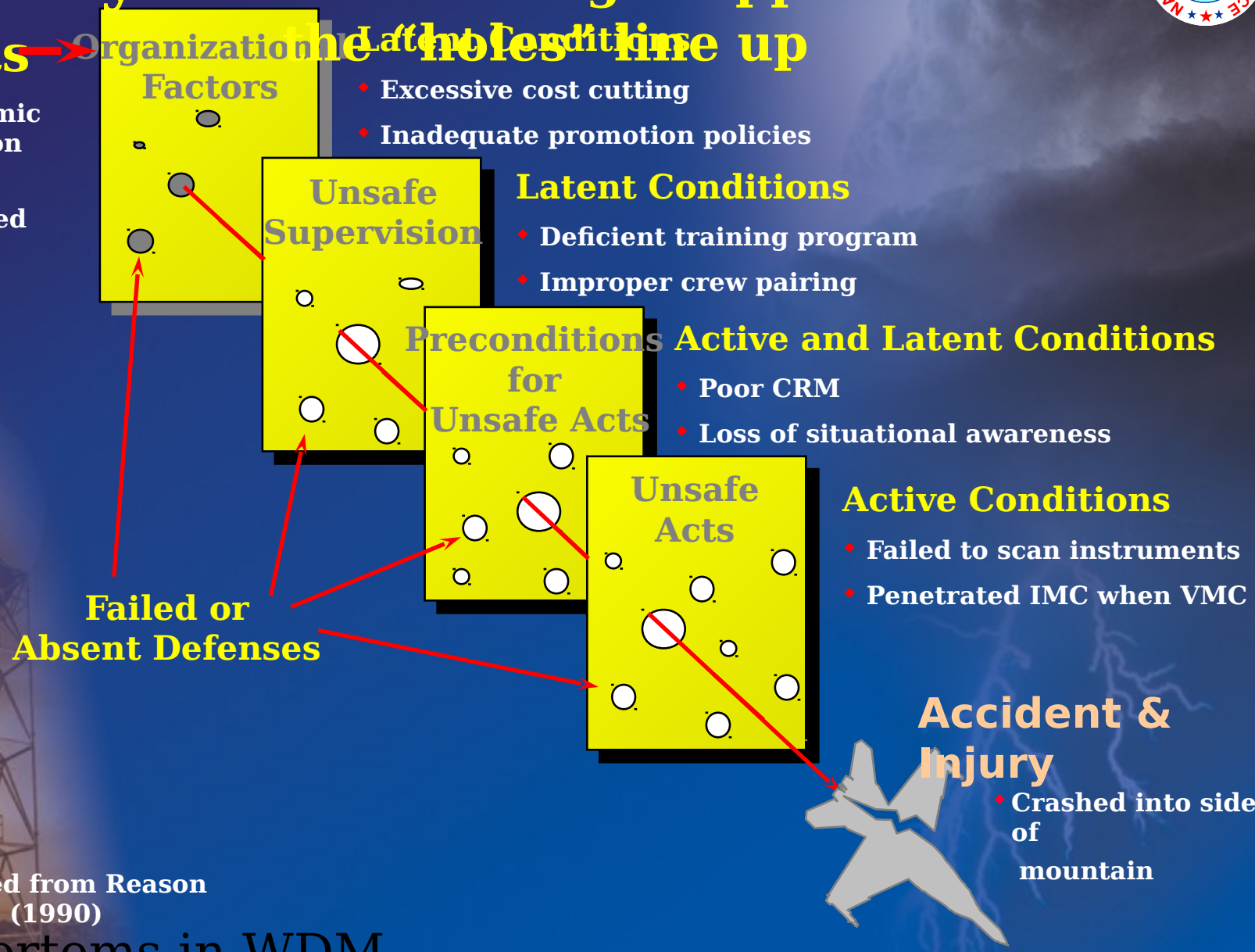
Principle 3: Blaming an error on the decision maker is like blaming a mechanical failure on the hardware.

Principle 4: An accident, no matter how minor, is a failure of the system.

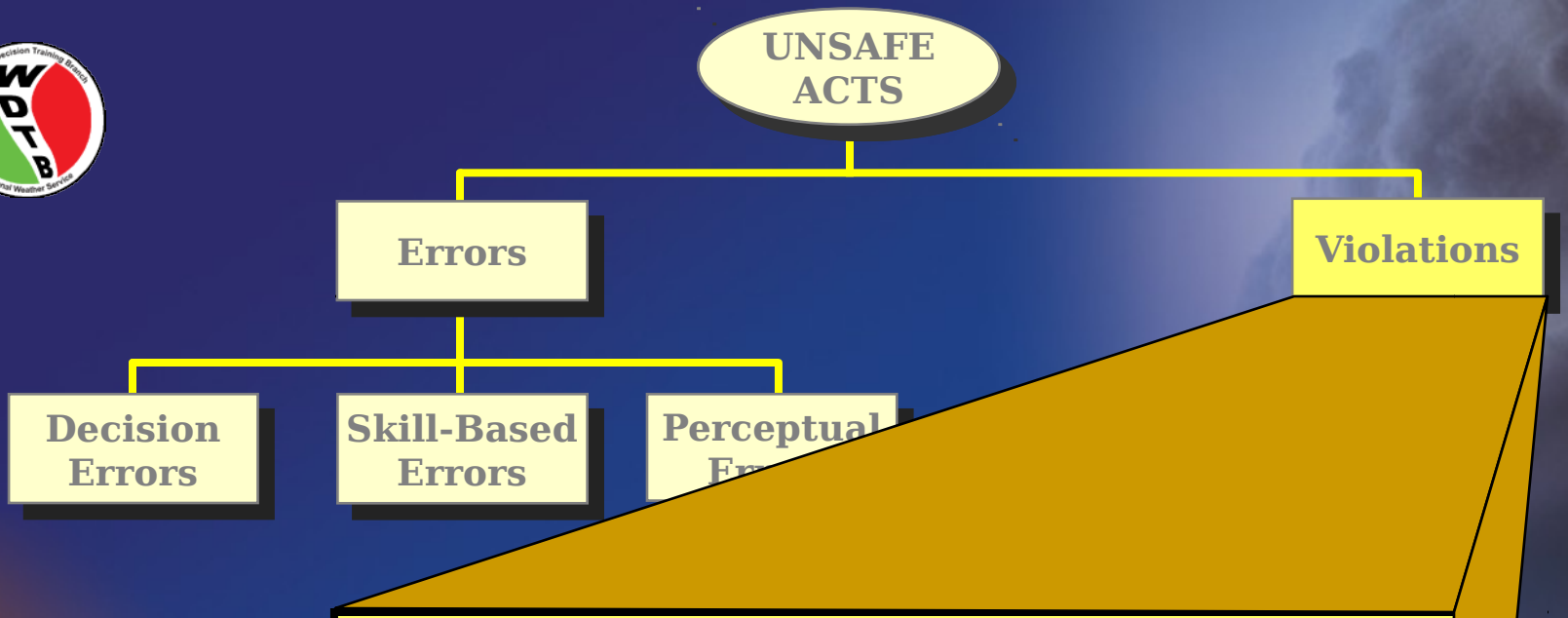
Principle 5: Accident investigation and error prevention go hand-in-hand.

Breakdown of a Productive System

Bad things happen when the holes line up

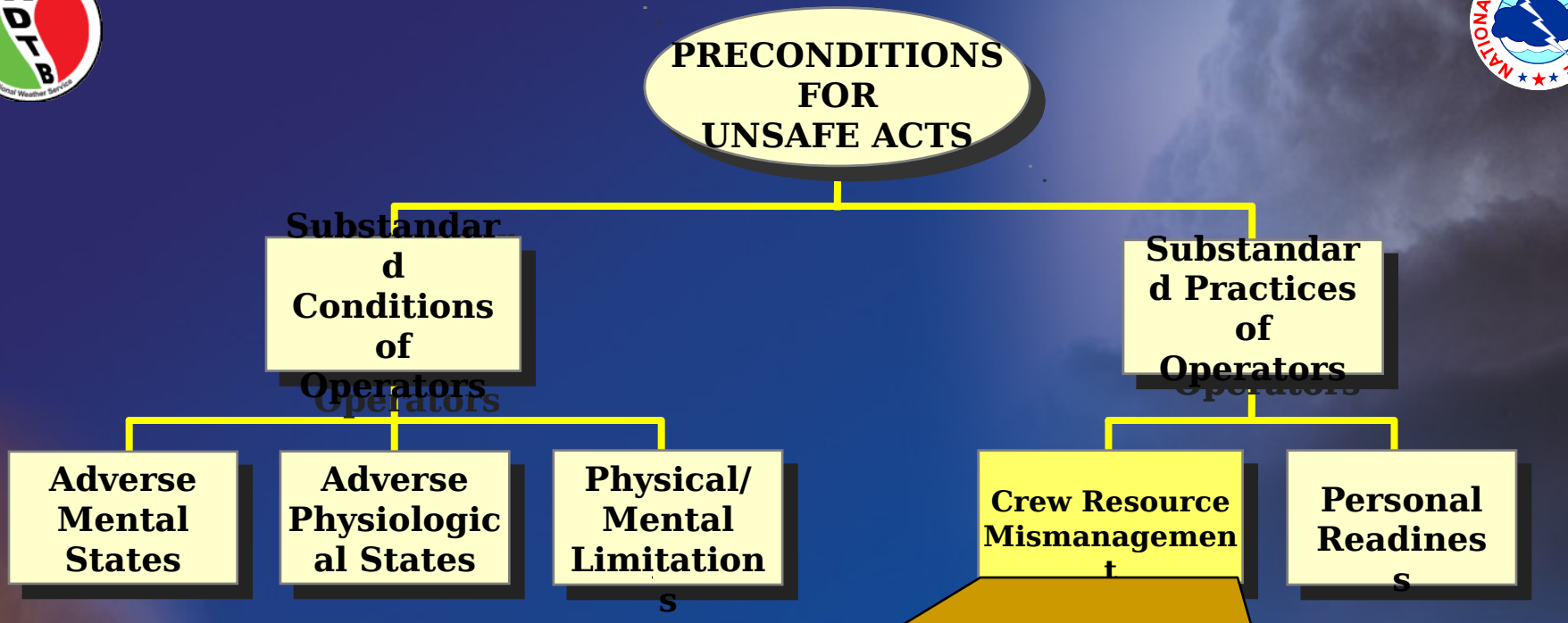


Adapted from Reason (1990)



VIOLATIONS

- **Violation of Orders/Regulations/SOP**
  - **Failed to Inspect ACFT after In-Flight Caution L ht**
  - **Violated Squadron SOP Restricting Flight Below 00'**
  - **Failed to Comply with NATOPS During Streamin**
  - **Conducted Night Training and Ops Mission with PAX**
  - **Elected to File VFR in Marginal Weather Condit ns**
  - **Failed to Use Radar Advisories from ATC**
  - **Inadequate Brief and Limits on Mission**
  - **HAC Knowingly Accepted Non-Current Crew**
- **Failed to Adhere to Brief**
- **Not Current/Qualified for Mission**
- **Improper Procedure**



CREW RESOURCE MISMANAGEMENT

- Not Working as a Team
- Poor Aircrew Coordination
- Improper Briefing Before a Mission
- Inadequate Coordination of Flight

Another way to assess data…

	USMC n=73	
	Count	(%)
Organizational Influences		
Resource Management	17	(23)
Organizational Climate	0	(0)
Organizational Process	19	(26)
Unsafe Supervision		
Inadequate Supervision	18	(25)
Planned Inappropriate Operations	9	(12)
Failed to Correct a Known Problem	4	(5)
Supervisory Violations	8	(11)
Preconditions for Unsafe Acts		
Adverse Mental States	57	(78)
Adverse Physiological States	18	(25)
Physical/Mental Limitations	7	(10)
Crew Resource Mismanagement	40	(55)
Personal Readiness	2	(3)
Unsafe Acts		
Decision Errors	36	(49)
Skill-based Errors	38	(52)
Perceptual Errors	23	(32)
Violations	22	(30)

Number and (Percentage) of Mishaps Associated with Each HFACS Category (FY 91-99)

II. NWS Post-Mortems

Examples of local office post-mortem content

- Capture event via warning logs, telephone logs
- Compute statistics (FAR,CSI, POD, LT, number of reports outside/inside warned counties)
- Describe synoptic setting, model performance, evolving mesoscale and stormscale situation, radar trends and observations
- Note equipment performance (WARNGEN, AWIPS, etc)
- General comments, constructive criticism and other suggestions

NWS Post-Mortems

Examples of local office post-mortem content…cont

- Forms completed after any event where a warning is issued (whether or not it verifies)
- Presentation available within 1 day of event for staff viewing

NWS Post-Mortem

Some official post-mortem formats

Significant Operations (SIG OPS)

- Deaths
- Injuries
- Damage
- Watches
- Warnings
- Service
- Systems
- Response

For the Record

- Event description
- Deaths (time,location, age, etc)
- Additional details on deaths
- Injuries (number, time, age etc)
- Additional details on injuries
- Extent of damage
- Watches, incl aerial extent
- Warnings (type, lead time)
- Evacuations

Applied to Event "X"

First severe weather outbreak of the year with a considerable number of storms to manage. Tornado struck. No warning in effect. One death and several injuries.

Significant Operations (SIG OPS)

Deaths: 1

Injuries: 6

Damage: 300K

Watches: Tornado

Warnings: None

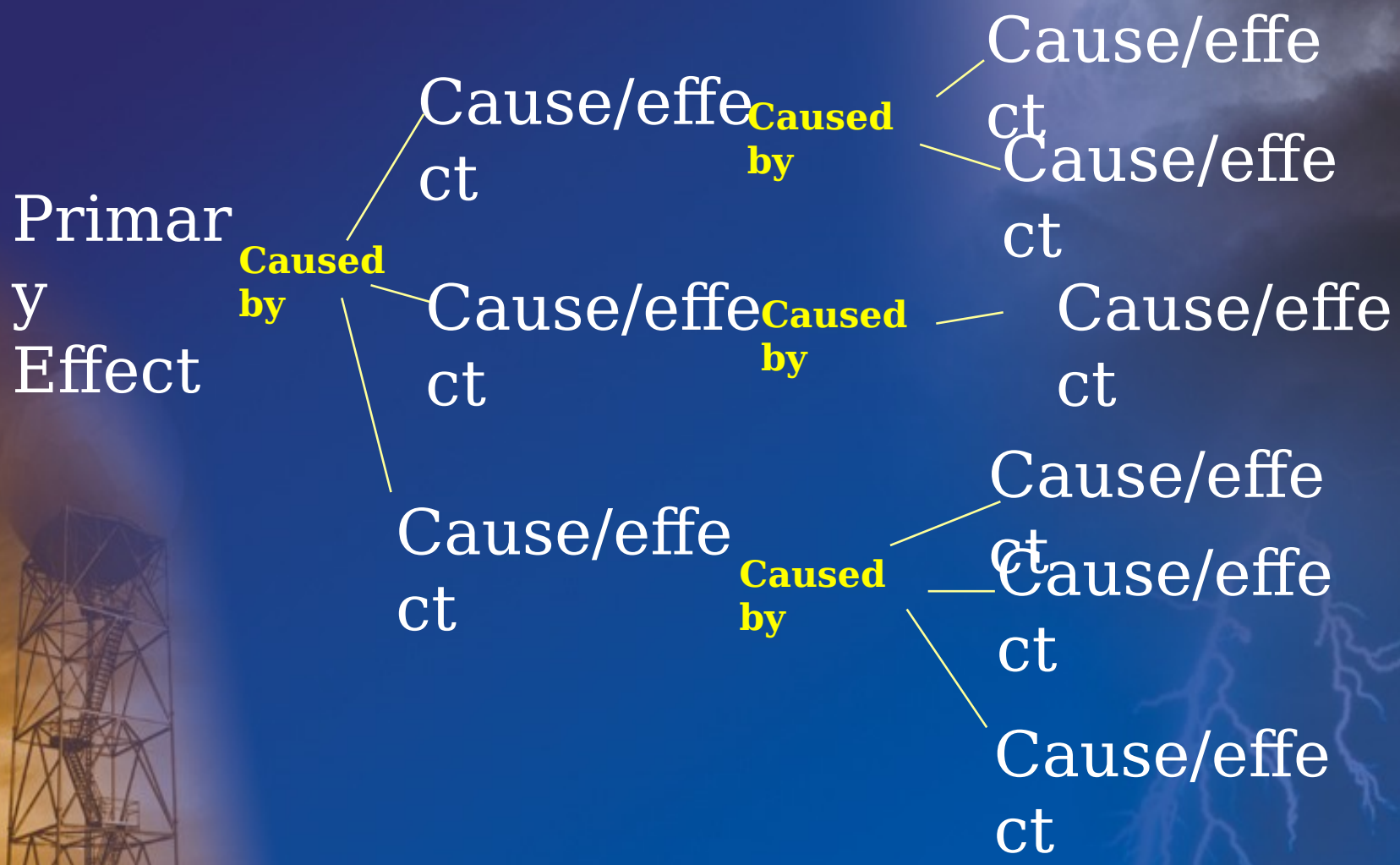
Service: Tor warning for storm in upstream county. Warning re-issued when report arrived.

Systems: Functioning properly

Response: Covered initially

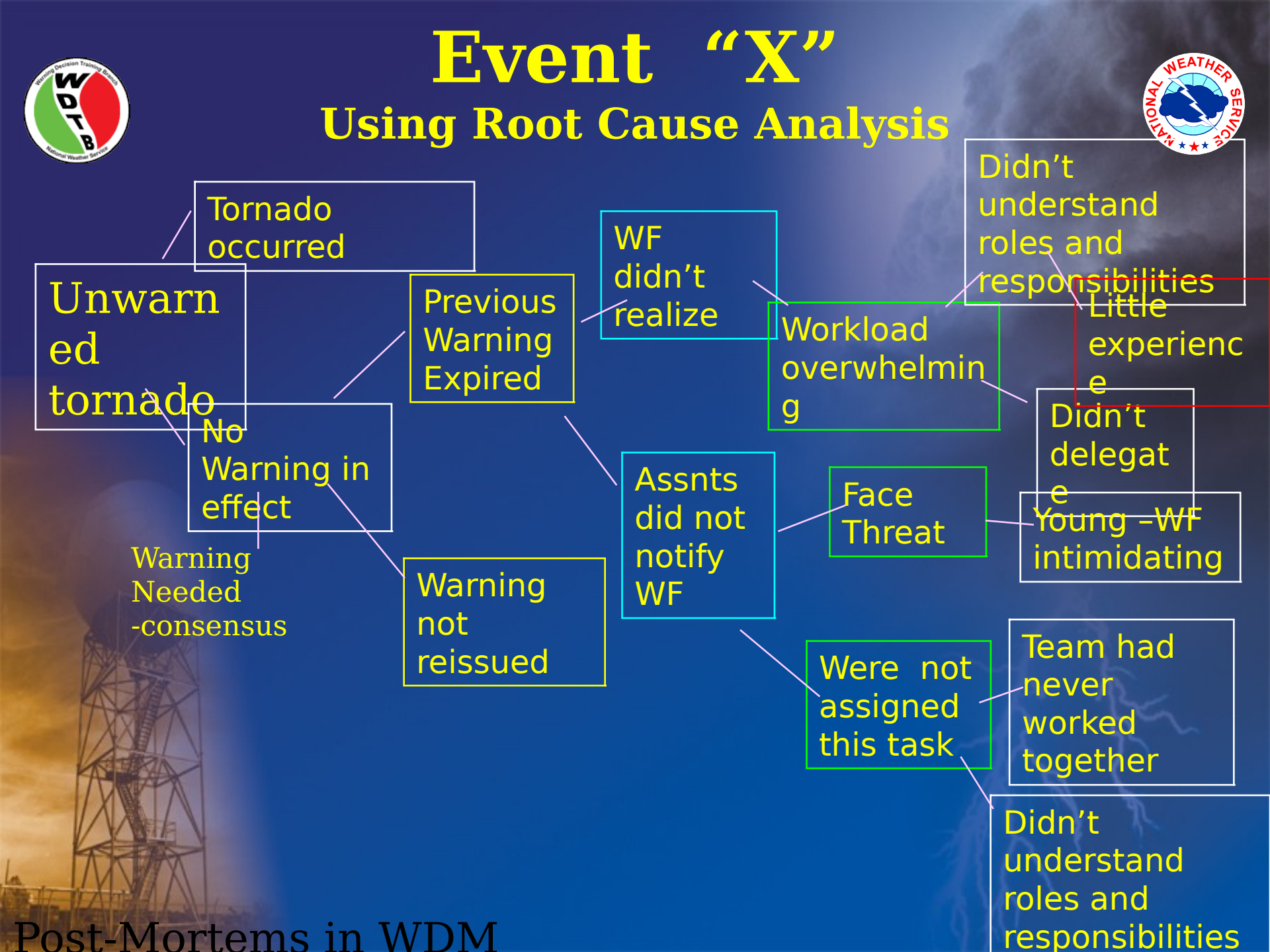
Another way to diagnose

Root Cause Analysis

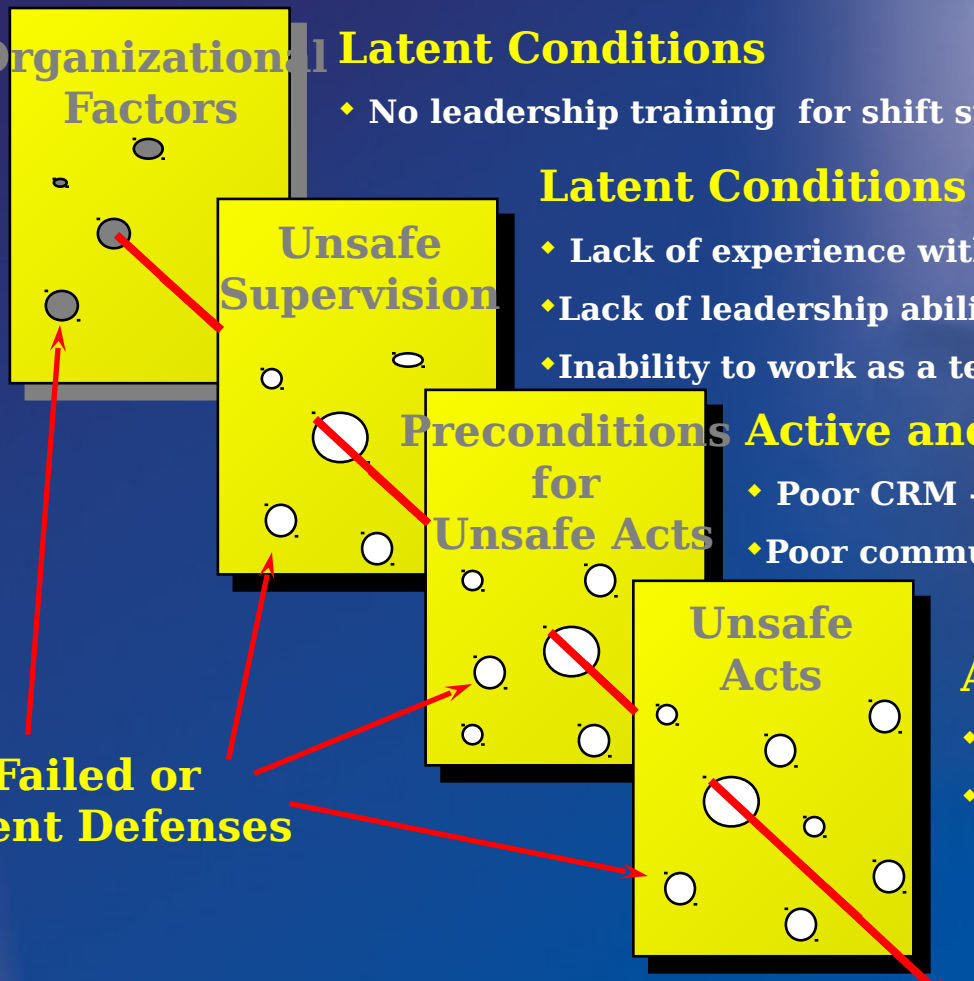


Event "X"

Using Root Cause Analysis



HFACS: Event "X"



Latent Conditions

- No leadership training for shift supervisors

Latent Conditions

- Lack of experience with severe weather
- Lack of leadership ability
- Inability to work as a team

Active and Latent Conditions

- Poor CRM – no work delegated
- Poor communication – face threat

Active Conditions

- Storms not being managed
- Warning accidentally allowed t

Unwarned tornado

- Death and injury

Summary

In order to be effective, post-mortems must be:

Completely forthright

- ***Is this possible? Will it take a third party?***

"We have learned the futility of trying to UNDERSTAND when people are afraid of BLAME."

B. Nelms, FAILSAFE Network

Summary…cont

A post-mortem *template* should:

- Be timely
- Be quick
- Be thorough
  - Capture science, technology, human aspects
- Provide an opportunity to go in depth if desired
  - Interviews
  - Root cause analysis, for ex
- Provide input into a larger database

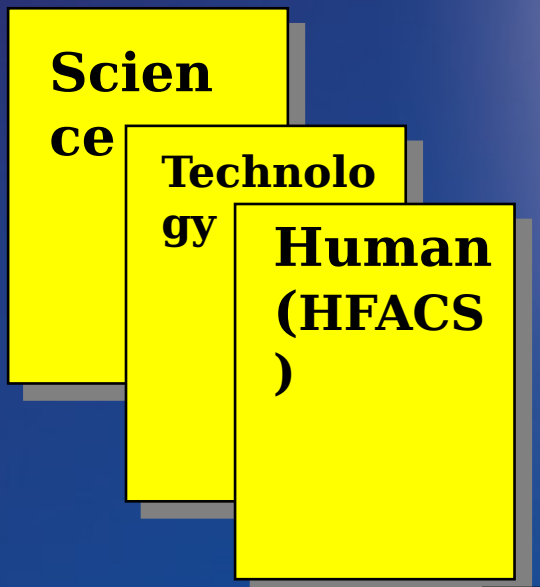
Summary…cont

A data base (as illustrated by HFACS) can:

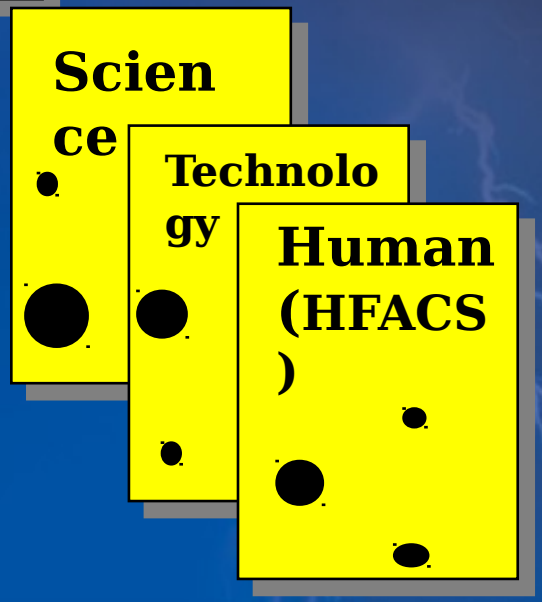
- Highlight important issues and their interrelationships
  - Help define the “holes” in the cheese as well as how and why they line up
- Help target the need for specific intervention strategies
  - Can be used to prevent incidents before they occur
- Provide enlightenment as to the larger scale global issues

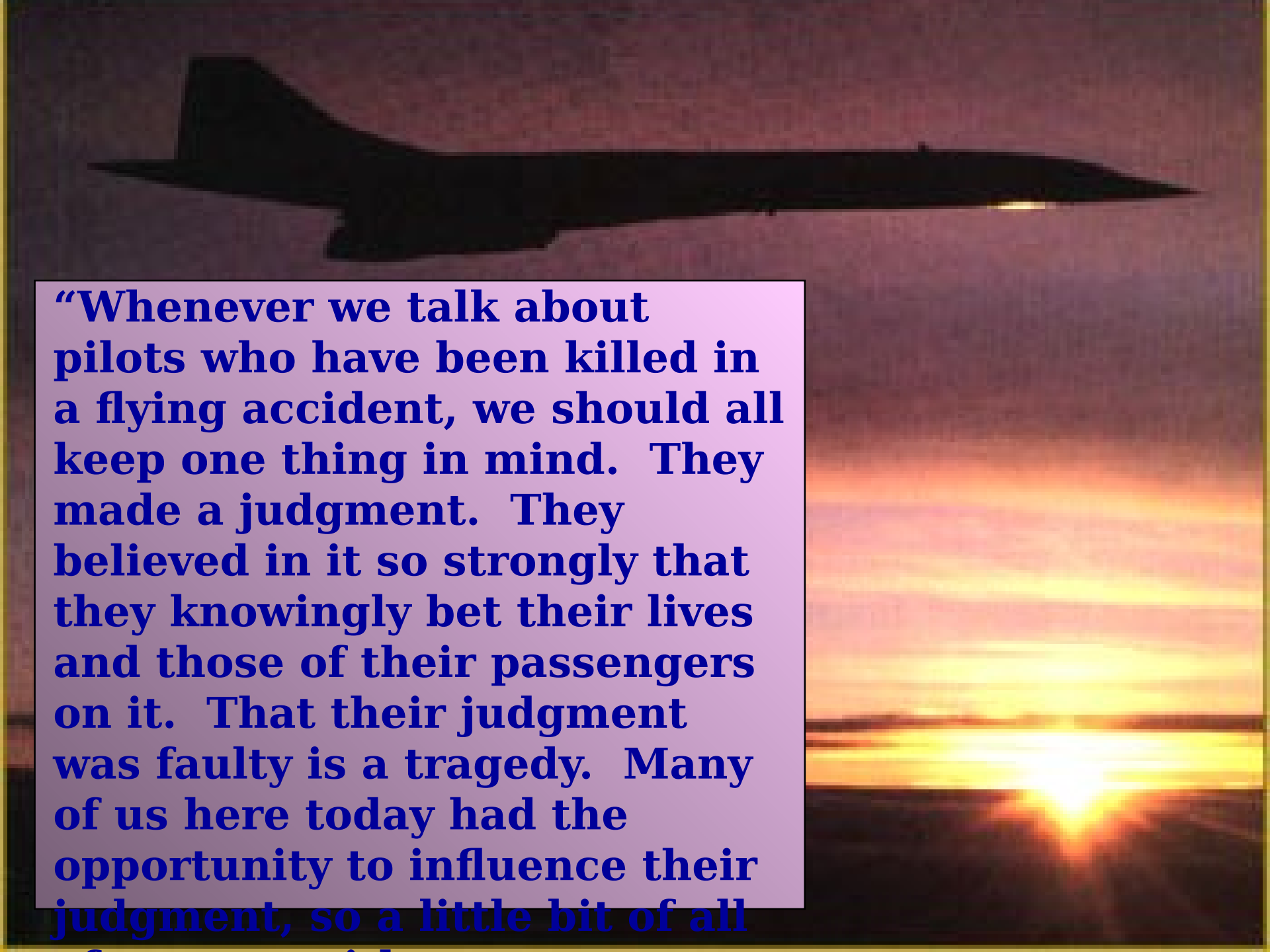
SUMMARY…cont
What about NWS?

What are our "cheese" slices?



What are our "holes"?





“Whenever we talk about pilots who have been killed in a flying accident, we should all keep one thing in mind. They made a judgment. They believed in it so strongly that they knowingly bet their lives and those of their passengers on it. That their judgment was faulty is a tragedy. Many of us here today had the opportunity to influence their judgment, so a little bit of all

Questions?

Post-Mortems in WDM

References

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III. Post-Mortems
Group Assignments

Goal: Begin process of developing a template for Post-Mortems.

Consider: Content, Forms, Access, Implementation

III. Post-Mortems
Group Assignments

1. Science
   - Expectations met? Environment, Radar, etc
2. Technology
   - Functioning, useful, helped or hurt
3. Human Factors
   - Organizational, supervision, preconditions for unsafe acts, unsafe acts …others?
4. Event Summary
   - Stats, response
5. Implementation
   - When to use, who, how, when to go in depth